

(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property  
Organization  
International Bureau



(43) International Publication Date  
8 January 2004 (08.01.2004)

PCT

(10) International Publication Number  
**WO 2004/003337 A1**

(51) International Patent Classification<sup>7</sup>: **E21B 23/04,**  
23/08

Paul [US/US]; 405 Westridge Drive, Duncan, OK 73533  
(US). RING, Lev [RU/US]; 14126 Heatherhill Place,  
Houston, TX 77077 (US).

(21) International Application Number:  
PCT/US2003/015020

(74) Agents: MATTINGLY, Todd et al.; Haynes and Boone,  
LLP, Suite 4300, 1000 Louisiana Street, Houston, TX  
77002-5012 (US).

(22) International Filing Date: 12 May 2003 (12.05.2003)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:  
60/391,703 26 June 2002 (26.06.2002) US

(81) Designated States (*national*): AE, AG, AI, AM, AT, AU,  
AZ, BA, BB, BG, BR, BY, BZ, CA, CH, CN, CO, CR, CU,  
CZ, DE, DK, DM, DZ, EC, EE, ES, FI, GB, GD, GE, GH,  
GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC,  
LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW,  
MX, MZ, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SK, SI,  
TJ, TM, TR, TT, TZ, UA, UG, US, UZ, VN, YU, ZA, ZW.

(71) Applicant (*for all designated States except US*): ENVEN-  
TURE GLOBAL TECHNOLOGY [US/US]; 16200 A.  
Park Row, Houston, TX 77084 (US).

(84) Designated States (*regional*): ARIPO patent (GH, GM,  
KE, LS, MW, MZ, SD, SL, SZ, TZ, UG, ZM, ZW),  
Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM),  
European patent (AT, BE, BG, CH, CY, CZ, DE, DK, EE,  
ES, FI, FR, GB, GR, HU, IE, IT, LU, MC, NL, PT, RO,

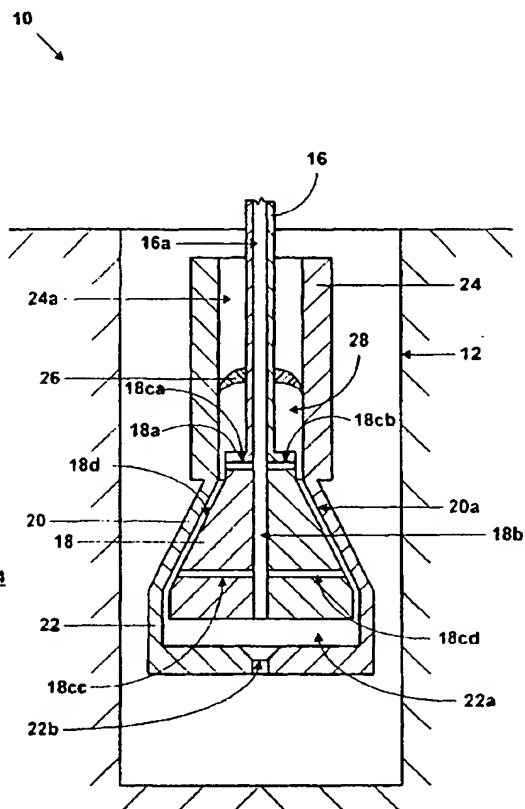
(72) Inventors; and

(75) Inventors/Applicants (*for US only*): BRISCO, David,

[Continued on next page]

(54) Title: SYSTEM FOR RADially EXPANDING A TUBULAR MEMBER

(57) Abstract: A system for radially expanding a tubular mem-  
ber (24).



BEST AVAILABLE COPY

WO 2004/003337 A1



SE, SI, SK, TR). OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

*For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.*

**Declaration under Rule 4.17:**

- *of inventorship (Rule 4.17(iv)) for US only*

**Published:**

- *with international search report*
- *with amended claims*

**SYSTEM FOR RADially EXPANDING A TUBULAR MEMBER****Cross Reference To Related Applications**

[001] The present application claims the benefit of the filing dates of (1) U.S. provisional patent application serial no. 60/391,703, attorney docket no 25791.90, filed on 6/26/2002, the disclosure of which is incorporated herein by reference

[002] The present application is related to the following: (1) U.S. patent application serial no. 09/454,139, attorney docket no. 25791.03.02, filed on 12/3/1999, (2) U.S. patent application serial no. 09/510,913, attorney docket no. 25791.7.02, filed on 2/23/2000, (3) U.S. patent application serial no. 09/502,350, attorney docket no. 25791.8.02, filed on 2/10/2000, (4) U.S. patent no. 6,328,113, (5) U.S. patent application serial no. 09/523,460, attorney docket no. 25791.11.02, filed on 3/10/2000, (6) U.S. patent application serial no. 09/512,895, attorney docket no. 25791.12.02, filed on 2/24/2000, (7) U.S. patent application serial no. 09/511,941, attorney docket no. 25791.16.02, filed on 2/24/2000, (8) U.S. patent application serial no. 09/588,946, attorney docket no. 25791.17.02, filed on 6/7/2000, (9) U.S. patent application serial no. 09/559,122, attorney docket no. 25791.23.02, filed on 4/26/2000, (10) PCT patent application serial no. PCT/US00/18635, attorney docket no. 25791.25.02, filed on 7/9/2000, (11) U.S. provisional patent application serial no. 60/162,671, attorney docket no. 25791.27, filed on 11/1/1999, (12) U.S. provisional patent application serial no. 60/154,047, attorney docket no. 25791.29, filed on 9/16/1999, (13) U.S. provisional patent application serial no. 60/159,082, attorney docket no. 25791.34, filed on 10/12/1999, (14) U.S. provisional patent application serial no. 60/159,039, attorney docket no. 25791.36, filed on 10/12/1999, (15) U.S. provisional patent application serial no. 60/159,033, attorney docket no. 25791.37, filed on 10/12/1999, (16) U.S. provisional patent application serial no. 60/212,359, attorney docket no. 25791.38, filed on 6/19/2000, (17) U.S. provisional patent application serial no. 60/165,228, attorney docket no. 25791.39, filed on 11/12/1999, (18) U.S. provisional patent application serial no. 60/221,443, attorney docket no. 25791.45, filed on 7/28/2000, (19) U.S. provisional patent application serial no. 60/221,645, attorney docket no. 25791.46, filed on 7/28/2000, (20) U.S. provisional patent application serial no. 60/233,638, attorney docket no. 25791.47, filed on 9/18/2000, (21) U.S. provisional patent application serial no. 60/237,334, attorney docket no. 25791.48, filed on 10/2/2000, (22) U.S. provisional patent application serial no. 60/270,007, attorney docket no. 25791.50, filed on 2/20/2001, (23) U.S. provisional patent application serial no. 60/262,434, attorney docket no. 25791.51, filed on 1/17/2001, (24) U.S. provisional patent application serial no. 60/259,486, attorney docket no. 25791.52, filed on 1/3/2001, (25) U.S. provisional patent application serial no. 60/303,740, attorney docket no. 25791.61, filed on 7/6/2001, (26) U.S. provisional patent application serial no. 60/313,453, attorney docket no. 25791.59, filed on 8/20/2001, (27) U.S. provisional patent application serial no. 60/317,985, attorney docket no. 25791.67, filed on 9/6/2001, (28) U.S. provisional patent application serial no. 60/331,836, attorney docket no. 25791.67.02, filed on 9/10/2001, (29) U.S. utility

---

patent application serial no. 09/969,922, attorney docket no. 25791.69, filed on 10/3/2001, (30) U.S. utility patent application serial no. 10/016,467, attorney docket no. 25791.70, filed on 12/10/2001, (31) U.S. provisional patent application serial no. 60/343,674, attorney docket no. 25791.68, filed on 12/27/2001, (32) U.S. provisional patent application serial no. 60/346,309, attorney docket no. 25791.92, filed on 1/7/2002, (33) U.S. provisional patent application serial no. 60/372,048, attorney docket no. 25791.93, filed on 4/12/2002, (34) U.S. provisional patent application serial no. 60/372,632, attorney docket no. 25791.101, filed on 4/15/2002, (35) U.S. provisional patent application serial no. 60/380,147, attorney docket no. 25791.104, filed on 5/6/2002, (36) U.S. provisional patent application serial no. 60/387,486, attorney docket no. 25791.107, filed on 6/10/2002, and (37) U.S. provisional patent application serial no. 60/387,961, attorney docket no. 25791.108, filed on 6/12/2002, the disclosures of which are incorporated herein by reference.

### **Background of the Invention**

[003] This invention relates generally to oil and gas exploration, and in particular to forming and repairing wellbore casings to facilitate oil and gas exploration and production.

[004] Conventionally, when a wellbore is created, a number of casings are installed in the borehole to prevent collapse of the borehole wall and to prevent undesired outflow of drilling fluid into the formation or inflow of fluid from the formation into the borehole. The borehole is drilled in intervals whereby a casing which is to be installed in a lower borehole interval is lowered through a previously installed casing of an upper borehole interval. As a consequence of this procedure the casing of the lower interval is of smaller diameter than the casing of the upper interval. Thus, the casings are in a nested arrangement with casing diameters decreasing in downward direction. Cement annuli are provided between the outer surfaces of the casings and the borehole wall to seal the casings from the borehole wall. As a consequence of this nested arrangement a relatively large borehole diameter is required at the upper part of the wellbore. Such a large borehole diameter involves increased costs due to heavy casing handling equipment, large drill bits and increased volumes of drilling fluid and drill cuttings. Moreover, increased drilling rig time is involved due to required cement pumping, cement hardening, required equipment changes due to large variations in hole diameters drilled in the course of the well, and the large volume of cuttings drilled and removed.

[005] The present invention is directed to overcoming one or more of the limitations of the existing processes for forming and repairing wellbore casings.

### **Summary of the Invention**

[006] According to one aspect of the present invention, a method of radially expanding a tubular member is provided that includes positioning an expansion cone within the tubular member, displacing the expansion cone relative to the tubular member, and during the displacement of the expansion cone relative to the tubular member, hydroplaning the tubular member on the expansion cone.

---

[007] According to another aspect of the present invention, a system for radially expanding a tubular member is provided that includes means for positioning an expansion cone within the tubular member, means for displacing the expansion cone relative to the tubular member, and during the displacement of the expansion cone relative to the tubular member, means for hydroplaning the tubular member on the expansion cone.

[008] According to another aspect of the present invention, an apparatus for radially expanding and plastically deforming a tubular member is provided that includes a tubular support member that defines a longitudinal passage, a tubular expansion cone coupled to an end of the tubular support member that defines a longitudinal passage and one or more radial passages that extend from the longitudinal passage and extend to an outer surface of the tubular expansion cone, a tubular expansion cone launcher that receives the tubular expansion cone, a tubular shoe coupled to an end of the tubular expansion cone launcher that defines a valveable longitudinal passage, an expandable tubular member coupled to another end of the tubular expansion cone launcher, and one or more cup seals coupled to the tubular support member for sealingly engaging the interior surface of the expandable tubular member.

#### **Brief Description of the Drawings**

[009] Fig. 1 is a fragmentary cross-sectional illustration of the placement of an apparatus for radially expanding a tubular member within a borehole that traverses a subterranean formation.

[0010] Figs. 2a and 2b are fragmentary cross-sectional illustrations of the apparatus of Fig. 1 after initiating the radial expansion and plastic deforming of the tubular member.

[0011] Fig. 3 is a graphical illustration of the unexpected result provided during the operation of the apparatus of Figs. 2a and 2b during the radial expansion and plastic deformation of the tubular member.

[0012] Fig. 4 is a fragmentary cross-sectional illustration of the apparatus of Figs. 2a and 2b after completing the radial expansion and plastic deformation of the tubular member.

#### **Detailed Description of the Illustrative Embodiments**

[0013] In an exemplary embodiment, as illustrated in Fig. 1, an apparatus 10 is positioned within a borehole 12 that traverses a subterranean formation 14 that may include a source of hydrocarbons and/or geothermal energy.

[0014] In an exemplary embodiment, the apparatus includes a tubular support member 16 that defines a longitudinal passage 16a. An upper end 18a of a tubular expansion cone 18 that defines a longitudinal passage 18b, radial passages, 18ca and 18cb, that extend from the longitudinal passage to the outer surface of the tubular expansion cone above a conical outer surface 18d, and radial passages, 18cc and 18cd, that extend from the longitudinal passage to the conical outer surface, is coupled to an end of the tubular support member 16. In this manner, fluidic materials may be conveyed from the passage 16a of the tubular support member 16 through the longitudinal passage 18b of the tubular expansion cone 18 and into the radial passages, 18ca, 18cb, 18cc, and 18cd, of the tubular expansion cone.

---

[0015] A tubular tapered expansion cone launcher 20 receives the outer conical surface 18d of the tubular expansion cone 18 within an interior passage 20a. In an exemplary embodiment, the interior surface of the tubular tapered expansion cone launcher 20 is a conical surface that is complementary shaped with respect to the outer conical surface 18d of the tubular expansion cone 18. An end of a tubular shoe 22 is coupled to an end of the tubular tapered expansion cone launcher 20 that defines an interior passage 22a and a valveable longitudinal passage 22b that may be adapted to receive a valve member such as, for example, a ball.

[0016] An end of an expandable tubular 24 that defines an internal passage 24a is coupled to another end of the tubular tapered expansion cone launcher 20. In an exemplary embodiment, the wall thickness of the expandable tubular 24 is greater than the wall thickness of the tubular tapered expansion cone launcher 20. In this manner, the initiation of the radial expansion of the expandable tubular member 24 is facilitated and the apparatus 10 may be positioned within wellbores 12 having tight radial clearances relative to the expansion cone launcher 20.

[0017] A resilient GuibersonJ sealing cup 26 is coupled to the exterior of the tubular support 16. In an exemplary embodiment, during operation of the apparatus 10, the sealing cup 26 engages the interior surface of the expandable tubular member 24 and thereby defines an annular chamber 28 between the exterior of the tubular support 16 and the interior of the expandable tubular member above the tubular expansion cone 18.

[0018] In an exemplary embodiment, as illustrated in Figs. 2a and 2b, during operation of the apparatus 10, a ball 30 is placed in the valveable passage 22b of the shoe 22 by injecting a fluidic material 32 into the apparatus 10 through the passages 16a and 18b. In this manner, the interior 22a of the tubular shoe 22 below the tubular expansion cone 18 and the annular chamber 28 above the tubular expansion cone below the GuibersonJ cup seal 26 may both be pressurized. In particular, continued injection of the fluidic material 32 into the apparatus 10 through the passages 16a and 18b will pressurize the interior of the tubular shoe 22 below the tubular expansion cone 18 as well as the annular chamber 28 above the tubular expansion cone below the GuibersonJ cup seal 26. As a result, the tubular expansion cone 18 will be displaced upwardly in the longitudinal direction relative to the tubular expansion cone launcher 20, the tubular shoe 22, and the expandable tubular member 24. In particular, the pressurization of the annular chamber 28 will cause the GuibersonJ cup seal 26 to pull the tubular expansion cone 18 upwardly out of the apparatus 10. Furthermore, the pressurization of the interior 22a of the tubular shoe 22 below the tubular expansion cone 18 will push the tubular expansion cone upwardly out of the apparatus 10. As a result, the tubular expansion cone launcher 20 and the expandable tubular member 24 are radially expanded and plastically deformed.

[0019] In an exemplary embodiment, during the radial expansion and plastic deformation of the tubular expansion cone launcher 20 and the expandable tubular member 24, the fluidic material 32 is conveyed through the radial passages, 18ca, 18cb, 18cc, and 18cd, into the annulus 34 defined between

the conical exterior surface 18d of the tubular expansion cone 18 and the interior surfaces of the tubular expansion cone launcher 20 and/or the expandable tubular member 24. As an unexpected result, the tubular expansion cone launcher 20 and/or the expandable tubular member 24 hydroplane on the conical outer surface 18d of the tubular expansion cone 18 during the radial expansion and plastic deformation of the tubular expansion cone launcher and expandable tubular member. During exemplary experimental testing of the apparatus 10, the unexpected hydroplaning of the expansion cone launcher 20 and/or the expandable tubular member 24 hydroplane on the conical outer surface 18d of the tubular expansion cone 18 during the radial expansion and plastic deformation of the tubular expansion cone launcher and expandable tubular member provided the further unexpected result of reducing the operating pressure of the fluidic material 32 required to radially expand and plastically deform the tubular expansion cone launcher 20 and/or the expandable tubular member 24. In an exemplary experimental test of the apparatus 10, the operating pressure within the annulus 34 was approximately equal to the operating pressures within the apparatus 10 below the tubular expansion cone 18 and within the annular chamber 28.

[0020] As illustrated in Fig. 3, the curve 100 illustrates typical required operating pressures of the fluidic material 32 in order to radially expand and plastically deform the tubular expansion cone launcher 20 and/or the expandable tubular member 24 for a range of angles of attack of the conical outer surface 18d of the tubular expansion cone 18. As will be recognized by persons having ordinary skill in the art, the angle of the attack of the conical outer surface 18d of the tubular expansion cone 18 refers to the angle of inclination of the conical outer surface relative to the longitudinal direction. By contrast, the curve 102 illustrates typical required operating pressures of the fluidic material 32 in order to radially expand and plastically deform the expandable tubular member 24 for a range of angles of attack of the conical outer surface 18d of the tubular expansion cone 18 where the radial passages, 18ca, 18cb, 18cc, and 18cd, were omitted from the tubular expansion cone. Unexpectedly, the omission of the radial passages, 18ca, 18cb, 18cc, and 18cd, from the tubular expansion cone 18 of the apparatus 10 significantly increased the required operating pressures of the fluidic material 32 in order to radially expand and plastically deform the expandable tubular member 24 across the range of angles of attack of the conical outer surface 18d of the tubular expansion cone 18. Thus, the unexpected hydroplaning of the expansion cone launcher 20 and the expandable tubular member 24 hydroplane on the conical outer surface 18d of the tubular expansion cone 18 during the radial expansion and plastic deformation of the tubular expansion cone launcher and expandable tubular member provided the further unexpected result of reducing the operating pressure of the fluidic material 32 required to radially expand and plastically deform the tubular expansion cone launcher and/or the expandable tubular member.

---

[0021] In an exemplary embodiment, as illustrated in Fig. 4, after completing the radial expansion and plastic deformation of the tubular expansion cone launcher 20 and the expandable tubular member 24, the expandable tubular member is coupled to the interior surface of the borehole 12.

[0022] A method of radially expanding a tubular member has been described that includes positioning an expansion cone within the tubular member, displacing the expansion cone relative to the tubular member, and during the displacement of the expansion cone relative to the tubular member, hydroplaning the tubular member on the expansion cone. In an exemplary embodiment, displacing the expansion cone relative to the tubular member includes pulling the expansion cone through the tubular member using fluid pressure. In an exemplary embodiment, pulling the expansion cone through the tubular member using fluid pressure includes pressuring an annular chamber within the tubular member above the expansion cone. In an exemplary embodiment, displacing the expansion cone relative to the tubular member includes pushing the expansion cone through the tubular member using fluid pressure. In an exemplary embodiment, pushing the expansion cone through the tubular member using fluid pressure includes pressurizing a chamber within the tubular member below the expansion cone. In an exemplary embodiment, hydroplaning the tubular member on the expansion cone includes injecting a fluidic material into an annulus between the expansion cone and the tubular member. In an exemplary embodiment, the expansion cone includes a conical outer surface, and the fluidic material is injected into a portion of the annulus above the conical outer surface. In an exemplary embodiment, the expansion cone includes a conical outer surface, and the fluidic material is injected into a portion of the annulus bounded by the conical outer surface. In an exemplary embodiment, the expansion cone includes a conical outer surface, and the fluidic material is injected into a portion of the annulus above the conical outer surface and another portion of the annulus bounded by the conical outer surface. In an exemplary embodiment, displacing the expansion cone relative to the tubular member includes pulling the expansion cone through the tubular member using fluid pressure. In an exemplary embodiment, pulling the expansion cone through the tubular member using fluid pressure includes pressuring an annular chamber within the tubular member above the expansion cone. In an exemplary embodiment, the operating pressure of the annular chamber and the annulus are approximately equal. In an exemplary embodiment, displacing the expansion cone relative to the tubular member includes pushing the expansion cone through the tubular member using fluid pressure. In an exemplary embodiment, pushing the expansion cone through the tubular member using fluid pressure includes pressurizing a chamber within the tubular member below the expansion cone. In an exemplary embodiment, the operating pressure of the chamber and the annulus are approximately equal.

[0023] A system for radially expanding a tubular member has been described that includes means for positioning an expansion cone within the tubular member, means for displacing the expansion cone relative to the tubular member, and during the displacement of the expansion cone relative to the tubular member, means for hydroplaning the tubular member on the expansion cone. In an exemplary

---



embodiment, the means for displacing the expansion cone relative to the tubular member includes means for pulling the expansion cone through the tubular member using fluid pressure. In an exemplary embodiment, the means for pulling the expansion cone through the tubular member using fluid pressure includes means for pressuring an annular chamber within the tubular member above the expansion cone. In an exemplary embodiment, the means for displacing the expansion cone relative to the tubular member includes means for pushing the expansion cone through the tubular member using fluid pressure. In an exemplary embodiment, the means for pushing the expansion cone through the tubular member using fluid pressure includes means for pressurizing a chamber within the tubular member below the expansion cone. In an exemplary embodiment, the means for hydroplaning the tubular member on the expansion cone includes means for injecting a fluidic material into an annulus between the expansion cone and the tubular member. In an exemplary embodiment, the expansion cone includes a conical outer surface, and the means for injecting a fluidic material into the annulus between the expansion cone and the tubular member includes means for injecting a fluidic material a portion of the annulus above the conical outer surface. In an exemplary embodiment, the expansion cone includes a conical outer surface, and the means for injecting a fluidic material into the annulus between the expansion cone and the tubular member includes means for injecting a fluidic material into a portion of the annulus bounded by the conical outer surface. In an exemplary embodiment, the expansion cone includes a conical outer surface, and the means for injecting a fluidic material into the annulus between the expansion cone and the tubular member includes means for injecting a fluidic material into a portion of the annulus above the conical outer surface and another portion of the annulus bounded by the conical outer surface. In an exemplary embodiment, the means for displacing the expansion cone relative to the tubular member includes means for pulling the expansion cone through the tubular member using fluid pressure. In an exemplary embodiment, the means for pulling the expansion cone through the tubular member using fluid pressure includes means for pressuring an annular chamber within the tubular member above the expansion cone. In an exemplary embodiment, the operating pressure of the annular chamber and the annulus are approximately equal. In an exemplary embodiment, the means for displacing the expansion cone relative to the tubular member includes means for pushing the expansion cone through the tubular member using fluid pressure. In an exemplary embodiment, the means for pushing the expansion cone through the tubular member using fluid pressure includes means for pressurizing a chamber within the tubular member below the expansion cone. In an exemplary embodiment, the operating pressure of the chamber and the annulus are approximately equal.

[0024] An apparatus for radially expanding and plastically deforming a tubular member has been described that includes a tubular support member that defines a longitudinal passage, a tubular expansion cone coupled to an end of the tubular support member that defines a longitudinal passage and one or more radial passages that extend from the longitudinal passage and extend to an outer

---

surface of the tubular expansion cone, a tubular expansion cone launcher that receives the tubular expansion cone, a tubular shoe coupled to an end of the tubular expansion cone launcher that defines a valveable longitudinal passage, an expandable tubular member coupled to another end of the tubular expansion cone launcher, and one or more cup seals coupled to the tubular support member for sealingly engaging the interior surface of the expandable tubular member. In an exemplary embodiment, the tubular expansion cone includes a tapered outer surface and a non tapered outer surface, and at least one of the radial passages extend to the non tapered outer surface. In an exemplary embodiment, at least one of the radial passages extend to the tapered outer surface. In an exemplary embodiment, the tubular expansion cone includes a tapered outer surface and a non tapered outer surface; wherein at least one of the radial passages extend to the non tapered outer surface, and at least one other of the radial passages extend to the tapered outer surface.

[0025] It is understood that variations may be made in the foregoing without departing from the scope of the invention. For example, the teachings of the present illustrative embodiments may be used to provide a wellbore casing, a pipeline, or a structural support. Furthermore, the elements and teachings of the various illustrative embodiments may be combined in whole or in part in some or all of the illustrative embodiments. In addition, the tubular expansion cone 18 may include one or more radial passages 18c extending from the longitudinal passage 18b to the exterior surface of the tubular expansion cone. Furthermore, the apparatus may include one or more GuibersonJ cup seals 26.

[0026] Although illustrative embodiments of the invention have been shown and described, a wide range of modification, changes and substitution is contemplated in the foregoing disclosure. In some instances, some features of the present invention may be employed without a corresponding use of the other features. Accordingly, it is appropriate that the appended claims be construed broadly and in a manner consistent with the scope of the invention.

---

**Claims**

What is claimed is:

1. A method of radially expanding a tubular member, comprising:  
positioning an expansion cone within the tubular member;  
displacing the expansion cone relative to the tubular member; and  
during the displacement of the expansion cone relative to the tubular member, hydroplaning the tubular member on the expansion cone.
  2. The method of claim 1, wherein displacing the expansion cone relative to the tubular member comprises:  
pulling the expansion cone through the tubular member using fluid pressure.
  3. The method of claim 2, wherein pulling the expansion cone through the tubular member using fluid pressure comprises:  
pressuring an annular chamber within the tubular member above the expansion cone.
  4. The method of claim 1, wherein displacing the expansion cone relative to the tubular member comprises:  
pushing the expansion cone through the tubular member using fluid pressure.
  5. The method of claim 4, wherein pushing the expansion cone through the tubular member using fluid pressure comprises:  
pressurizing a chamber within the tubular member below the expansion cone.
  6. The method of claim 1, wherein hydroplaning the tubular member on the expansion cone comprises:  
injecting a fluidic material into an annulus between the expansion cone and the tubular member.
  7. The method of claim 6, wherein the expansion cone comprises a conical outer surface; and wherein the fluidic material is injected into a portion of the annulus above the conical outer surface.
  8. The method of claim 6, wherein the expansion cone comprises a conical outer surface; and wherein the fluidic material is injected into a portion of the annulus bounded by the conical outer surface.
-

9. The method of claim 6, wherein the expansion cone comprises a conical outer surface; and wherein the fluidic material is injected into a portion of the annulus above the conical outer surface and another portion of the annulus bounded by the conical outer surface.
10. The method of claim 6, wherein displacing the expansion cone relative to the tubular member comprises:  
pulling the expansion cone through the tubular member using fluid pressure.
11. The method of claim 10, wherein pulling the expansion cone through the tubular member using fluid pressure comprises:  
pressuring an annular chamber within the tubular member above the expansion cone.
12. The method of claim 11, wherein the operating pressure of the annular chamber and the annulus are approximately equal.
13. The method of claim 6, wherein displacing the expansion cone relative to the tubular member comprises:  
pushing the expansion cone through the tubular member using fluid pressure.
14. The method of claim 13, wherein pushing the expansion cone through the tubular member using fluid pressure comprises:  
pressurizing a chamber within the tubular member below the expansion cone.
15. The method of claim 14, wherein the operating pressure of the chamber and the annulus are approximately equal.
16. A system for radially expanding a tubular member, comprising:  
means for positioning an expansion cone within the tubular member;  
means for displacing the expansion cone relative to the tubular member; and  
during the displacement of the expansion cone relative to the tubular member, means for hydroplaning the tubular member on the expansion cone.
17. The system of claim 16, wherein means for displacing the expansion cone relative to the tubular member comprises:  
means for pulling the expansion cone through the tubular member using fluid pressure.
-

18. The system of claim 17, wherein means for pulling the expansion cone through the tubular member using fluid pressure comprises:

means for pressuring an annular chamber within the tubular member above the expansion cone.

19. The system of claim 16, wherein means for displacing the expansion cone relative to the tubular member comprises:

means for pushing the expansion cone through the tubular member using fluid pressure.

20. The system of claim 19, wherein means for pushing the expansion cone through the tubular member using fluid pressure comprises:

means for pressurizing a chamber within the tubular member below the expansion cone.

21. The system of claim 16, wherein means for hydroplaning the tubular member on the expansion cone comprises:

means for injecting a fluidic material into an annulus between the expansion cone and the tubular member.

22. The system of claim 21, wherein the expansion cone comprises a conical outer surface; and wherein the means for injecting a fluidic material into the annulus between the expansion cone and the tubular member comprises means for injecting a fluidic material a portion of the annulus above the conical outer surface.

23. The system of claim 21, wherein the expansion cone comprises a conical outer surface; and wherein the means for injecting a fluidic material into the annulus between the expansion cone and the tubular member comprises means for injecting a fluidic material into a portion of the annulus bounded by the conical outer surface.

24. The system of claim 21, wherein the expansion cone comprises a conical outer surface; and wherein the means for injecting a fluidic material into the annulus between the expansion cone and the tubular member comprises means for injecting a fluidic material into a portion of the annulus above the conical outer surface and another portion of the annulus bounded by the conical outer surface.

25. The system of claim 21, wherein means for displacing the expansion cone relative to the tubular member comprises:

means for pulling the expansion cone through the tubular member using fluid pressure.

26. The system of claim 25, wherein means for pulling the expansion cone through the tubular member using fluid pressure comprises:

means for pressuring an annular chamber within the tubular member above the expansion cone.

27. The system of claim 26, wherein the operating pressure of the annular chamber and the annulus are approximately equal.

28. The system of claim 21, wherein means for displacing the expansion cone relative to the tubular member comprises:

means for pushing the expansion cone through the tubular member using fluid pressure.

29. The system of claim 28, wherein means for pushing the expansion cone through the tubular member using fluid pressure comprises:

means for pressurizing a chamber within the tubular member below the expansion cone.

30. The system of claim 29, wherein the operating pressure of the chamber and the annulus are approximately equal.

31. An apparatus for radially expanding and plastically deforming a tubular member, comprising:

a tubular support member that defines a longitudinal passage;

a tubular expansion cone coupled to an end of the tubular support member that defines a longitudinal passage and one or more radial passages that extend from the longitudinal passage and extend to an outer surface of the tubular expansion cone;

a tubular expansion cone launcher that receives the tubular expansion cone;

a tubular shoe coupled to an end of the tubular expansion cone launcher that defines a valveable longitudinal passage;

an expandable tubular member coupled to another end of the tubular expansion cone launcher;

and

one or more cup seals coupled to the tubular support member for sealingly engaging the interior surface of the expandable tubular member.

32. The apparatus of claim 31, wherein the tubular expansion cone comprises a tapered outer surface and a non tapered outer surface; and wherein at least one of the radial passages extend to the non tapered outer surface.

---

33. The apparatus of claim 32, wherein at least one of the radial passages extend to the tapered outer surface.

34. The apparatus of claim 31, wherein the tubular expansion cone comprises a tapered outer surface and a non tapered outer surface; wherein at least one of the radial passages extend to the non tapered outer surface; and wherein at least one other of the radial passages extend to the tapered outer surface.

---

**AMENDED CLAIMS**

**[Received by the International Bureau on 16 september 2003 (16.09.03)  
original claims 6,7 and 10-15 cancelled ;original claims 1,8 and 9 amended, claims 35-58  
added, remaining claims unchanged]**

What is claimed is:

1. A method of radially expanding a tubular member, comprising:  
positioning an expansion cone comprising a tapered exterior surface and non-tapered exterior surfaces positioned above and below the tapered exterior surface within the tubular member;  
defining an annulus between the tapered and non-tapered exterior surfaces of the expansion cone and the interior surfaces of the tubular member;  
displacing the expansion cone relative to the tubular member to radially expand and plastically deform the tubular member; and  
during the displacement of the expansion cone relative to the tubular member, injecting fluidic material through the non-tapered exterior surface of the expansion cone above the tapered exterior surface of the expansion cone into the annulus and conveying the fluidic material through the remaining length of the annulus.
2. The method of claim 1, wherein displacing the expansion cone relative to the tubular member comprises:  
pulling the expansion cone through the tubular member using fluid pressure.
3. The method of claim 2, wherein pulling the expansion cone through the tubular member using fluid pressure comprises:  
pressuring an annular chamber within the tubular member above the expansion cone.
4. The method of claim 1, wherein displacing the expansion cone relative to the tubular member comprises:  
pushing the expansion cone through the tubular member using fluid pressure.
5. The method of claim 4, wherein pushing the expansion cone through the tubular member using fluid pressure comprises:  
pressurizing a chamber within the tubular member below the expansion cone.
6. Cancelled
7. Cancelled
8. The method of claim 1, wherein the fluidic material is injected through the tapered exterior surface of the expansion cone into a portion of the annulus bounded by the tapered exterior surface.



9. The method of claim 1, wherein the fluidic material is injected through non-tapered exterior surface of the expansion cone above the tapered exterior surface of the expansion cone and the tapered exterior surface of the expansion cone into a portion of the annulus above the tapered exterior surface and another portion of the annulus bounded by the tapered exterior surface.

10. Cancelled

11. Cancelled

12. Cancelled

13. Cancelled

14. Cancelled

15. Cancelled

16. A system for radially expanding a tubular member, comprising:  
means for positioning an expansion cone within the tubular member;  
means for displacing the expansion cone relative to the tubular member; and  
during the displacement of the expansion cone relative to the tubular member, means for hydroplaning the tubular member on the expansion cone.

17. The system of claim 16, wherein means for displacing the expansion cone relative to the tubular member comprises:  
means for pulling the expansion cone through the tubular member using fluid pressure.

18. The system of claim 17, wherein means for pulling the expansion cone through the tubular member using fluid pressure comprises:  
means for pressuring an annular chamber within the tubular member above the expansion cone.

19. The system of claim 16, wherein means for displacing the expansion cone relative to the tubular member comprises:  
means for pushing the expansion cone through the tubular member using fluid pressure.

20. The system of claim 19, wherein means for pushing the expansion cone through the tubular member using fluid pressure comprises:  
means for pressurizing a chamber within the tubular member below the expansion cone.

21. The system of claim 16, wherein means for hydroplaning the tubular member on the expansion cone comprises:  
means for injecting a fluidic material into an annulus between the expansion cone and the tubular member.

22. The system of claim 21, wherein the expansion cone comprises a conical outer surface; and wherein the means for injecting a fluidic material into the annulus between the expansion cone and the tubular member comprises means for injecting a fluidic material a portion of the annulus above the conical outer surface.

23. The system of claim 21, wherein the expansion cone comprises a conical outer surface; and wherein the means for injecting a fluidic material into the annulus between the expansion cone and the tubular member comprises means for injecting a fluidic material into a portion of the annulus bounded by the conical outer surface.

24. The system of claim 21, wherein the expansion cone comprises a conical outer surface; and wherein the means for injecting a fluidic material into the annulus between the expansion cone and the tubular member comprises means for injecting a fluidic material into a portion of the annulus above the conical outer surface and another portion of the annulus bounded by the conical outer surface.

25. The system of claim 21, wherein means for displacing the expansion cone relative to the tubular member comprises:  
means for pulling the expansion cone through the tubular member using fluid pressure.

26. The system of claim 25, wherein means for pulling the expansion cone through the tubular member using fluid pressure comprises:  
means for pressuring an annular chamber within the tubular member above the expansion cone.

27. The system of claim 26, wherein the operating pressure of the annular chamber and the annulus are approximately equal.

28. The system of claim 21, wherein means for displacing the expansion cone relative to the

tubular member comprises:

means for pushing the expansion cone through the tubular member using fluid pressure.

29. The system of claim 28, wherein means for pushing the expansion cone through the tubular member using fluid pressure comprises:

means for pressurizing a chamber within the tubular member below the expansion cone.

30. The system of claim 29, wherein the operating pressure of the chamber and the annulus are approximately equal.

31. An apparatus for radially expanding and plastically deforming a tubular member, comprising:

a tubular support member that defines a longitudinal passage;

a tubular expansion cone coupled to an end of the tubular support member that defines a longitudinal passage and one or more radial passages that extend from the longitudinal passage and extend to an outer surface of the tubular expansion cone;

a tubular expansion cone launcher that receives the tubular expansion cone;

a tubular shoe coupled to an end of the tubular expansion cone launcher that defines a valveable longitudinal passage;

an expandable tubular member coupled to another end of the tubular expansion cone launcher; and

one or more cup seals coupled to the tubular support member for sealingly engaging the interior surface of the expandable tubular member.

32. The apparatus of claim 31, wherein the tubular expansion cone comprises a tapered outer surface and a non tapered outer surface; and wherein at least one of the radial passages extend to the non tapered outer surface.

33. The apparatus of claim 32, wherein at least one of the radial passages extend to the tapered outer surface.

34. The apparatus of claim 31, wherein the tubular expansion cone comprises a tapered outer surface and a non tapered outer surface; wherein at least one of the radial passages extend to the non tapered outer surface; and wherein at least one other of the radial passages extend to the tapered outer surface.

35. A method of radially expanding a tubular member, comprising:

positioning an expansion device comprising an exterior expansion surface within the tubular member;  
defining an annulus between the exterior expansion surface of the expansion device and the interior surface of the tubular member;  
displacing the expansion device relative to the tubular member to radially expand and plastically deform the tubular member; and  
during the displacement of the expansion device relative to the tubular member, injecting fluidic material through expansion device into the annulus and conveying the fluidic material through the remaining length of the annulus.

36. The method of claim 35, wherein displacing the expansion device relative to the tubular member comprises:  
pulling the expansion device through the tubular member using fluid pressure.

37. The method of claim 36, wherein pulling the expansion device through the tubular member using fluid pressure comprises:  
pressuring an annular chamber within the tubular member above the expansion device.

38. The method of claim 35, wherein displacing the expansion device relative to the tubular member comprises:  
pushing the expansion device through the tubular member using fluid pressure.

39. The method of claim 38, wherein pushing the expansion device through the tubular member using fluid pressure comprises:  
pressurizing a chamber within the tubular member below the expansion device.

40. The method of claim 35, wherein the fluidic material is injected through the exterior expansion surface of the expansion device into a portion of the annulus bounded by the exterior expansion surface of the expansion device.

41. A system for radially expanding a tubular member, comprising:  
means for positioning an expansion device within the tubular member,  
means for displacing the expansion device relative to the tubular member, and  
during the displacement of the expansion device relative to the tubular member, means for hydroplaning the tubular member on the expansion device.

42. The system of claim 41, wherein means for displacing the expansion device relative to the tubular member comprises:  
means for pulling the expansion device through the tubular member using fluid pressure.
43. The system of claim 42, wherein means for pulling the expansion device through the tubular member using fluid pressure comprises:  
means for pressuring an annular chamber within the tubular member above the expansion device.
44. The system of claim 41, wherein means for displacing the expansion device relative to the tubular member comprises:  
means for pushing the expansion device through the tubular member using fluid pressure.
45. The system of claim 44, wherein means for pushing the expansion device through the tubular member using fluid pressure comprises:  
means for pressurizing a chamber within the tubular member below the expansion device.
46. The system of claim 41, wherein means for hydroplaning the tubular member on the expansion device comprises:  
means for injecting a fluidic material into an annulus between the expansion device and the tubular member.
47. The system of claim 46, wherein means for displacing the expansion device relative to the tubular member comprises:  
means for pulling the expansion device through the tubular member using fluid pressure.
48. The system of claim 47, wherein means for pulling the expansion device through the tubular member using fluid pressure comprises:  
means for pressuring an annular chamber within the tubular member above the expansion device.
49. The system of claim 48, wherein the operating pressure of the annular chamber and the annulus are approximately equal.
50. The system of claim 46, wherein means for displacing the expansion device relative to the tubular member comprises:  
means for pushing the expansion device through the tubular member using fluid pressure.

51. The system of claim 50, wherein means for pushing the expansion device through the tubular member using fluid pressure comprises:

means for pressurizing a chamber within the tubular member below the expansion device.

52. The system of claim 29, wherein the operating pressure of the chamber and the annulus are approximately equal.

53. An apparatus for radially expanding and plastically deforming a tubular member, comprising:

a tubular support member that defines a longitudinal passage;

an expansion device coupled to an end of the tubular support member that defines a longitudinal passage and one or more radial passages that extend from the longitudinal passage and extend to an outer surface of the expansion device;

a tubular expansion launcher that receives and mates with the expansion device;

an expandable tubular member coupled to an end of the tubular expansion launcher; and one or more cup seals coupled to the tubular support member for sealingly engaging the interior surface of the expandable tubular member.

54. The apparatus of claim 53, wherein the expansion device comprises a tapered outer surface and a non tapered outer surface; and wherein at least one of the radial passages extend to the non tapered outer surface.

55. The apparatus of claim 54, wherein at least one of the radial passages extend to the tapered outer surface.

56. The apparatus of claim 53, wherein the expansion device comprises a tapered outer surface and a non tapered outer surface; wherein at least one of the radial passages extend to the non tapered outer surface; and wherein at least one other of the radial passages extend to the tapered outer surface.

57. A method of radially expanding a tubular member, comprising:

positioning an expansion device within the tubular member;

defining an annulus between the expansion device and the tubular member;

displacing the expansion device relative to the tubular member in a first direction to radially expand and plastically deform the tubular member; and

during the displacement of the expansion device relative to the tubular member, injecting fluidic material through the expansion device into the annulus and conveying the fluidic material through the remaining length of the annulus in a second direction; wherein the first and second directions are opposite to one another.

58. A method of radially expanding a tubular member, comprising:  
positioning an expansion device within the tubular member;  
defining an annulus between the expansion device and the interior surface of the tubular member;  
displacing the expansion device relative to the tubular member to radially expand and plastically deform the tubular member; and  
during the displacement of the expansion device relative to the tubular member, pressurizing the annulus by injecting fluidic material through the expansion device into the annulus.

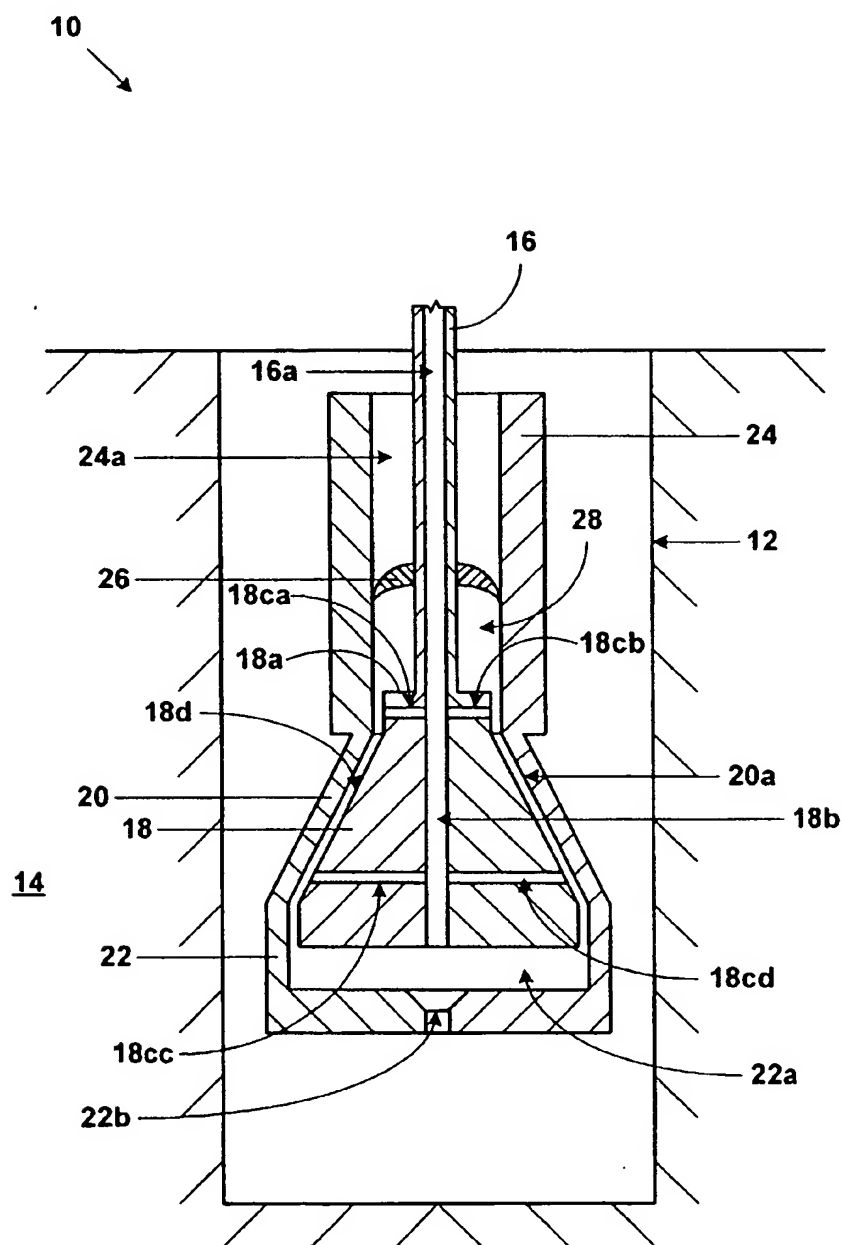


Fig. 1



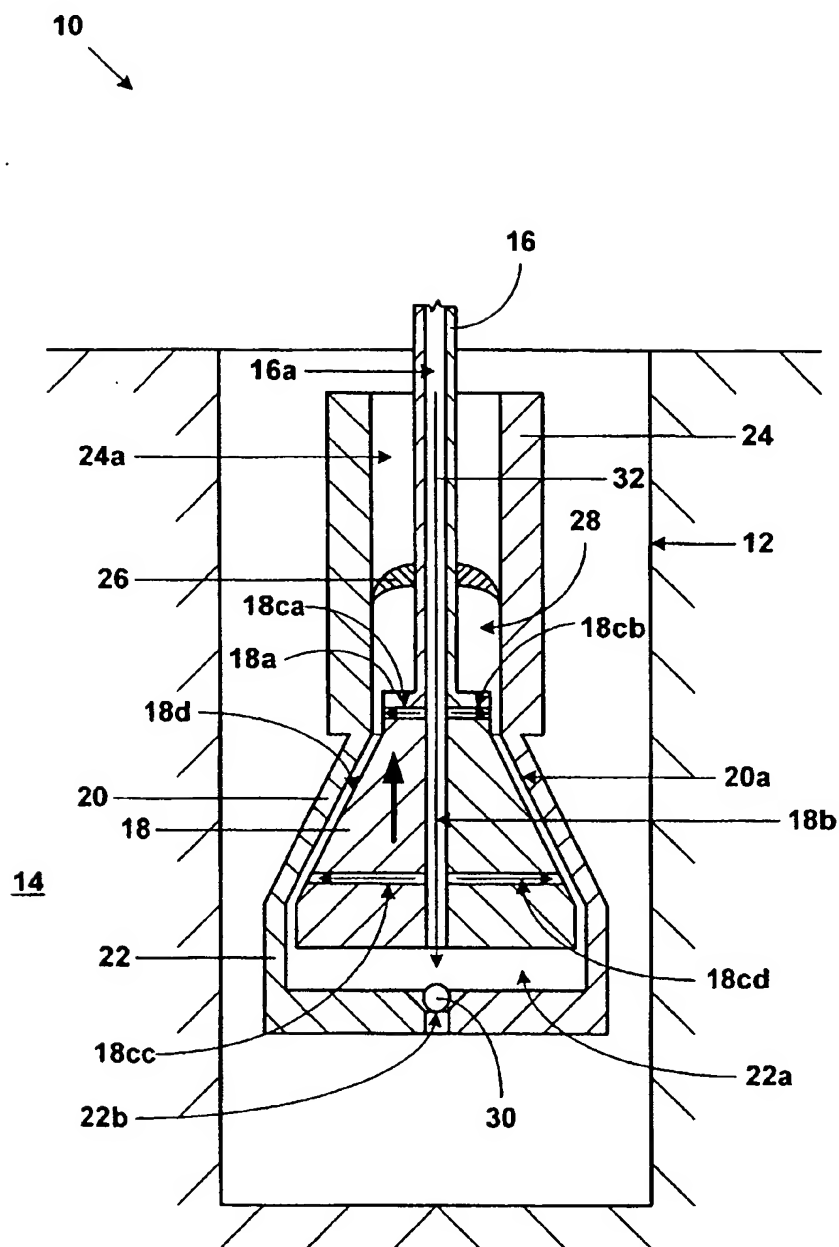


Fig. 2a

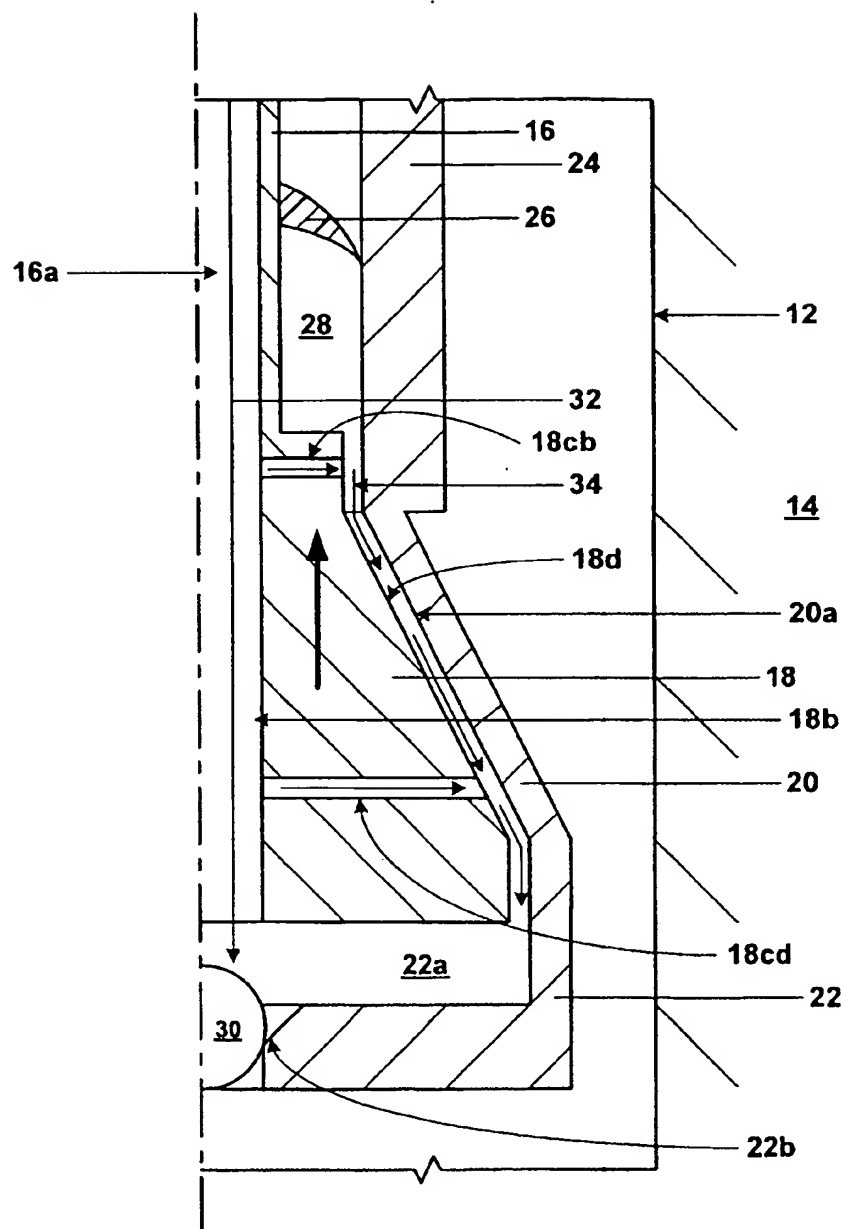
10  
↓

Fig. 2b

TYPICAL  
OPERATING  
PRESSURE  
FOR  
RADIAL  
EXPANSION  
OF TUBULAR

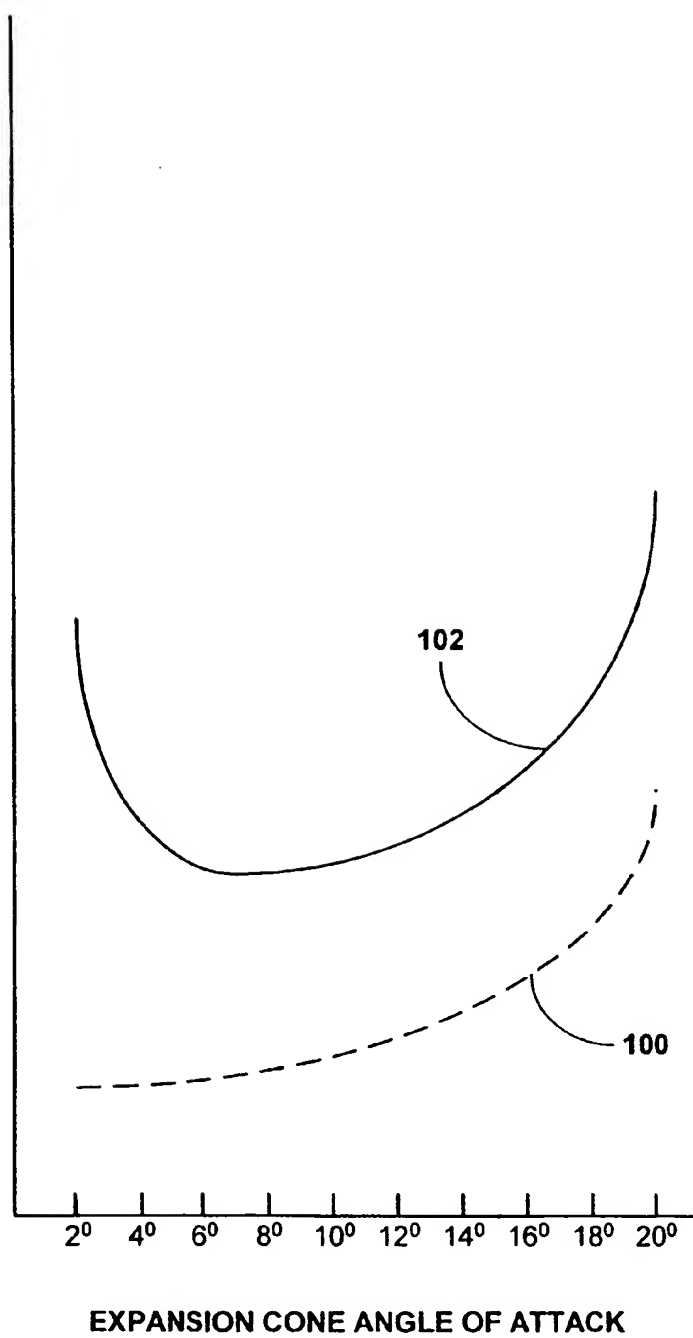


Fig. 3

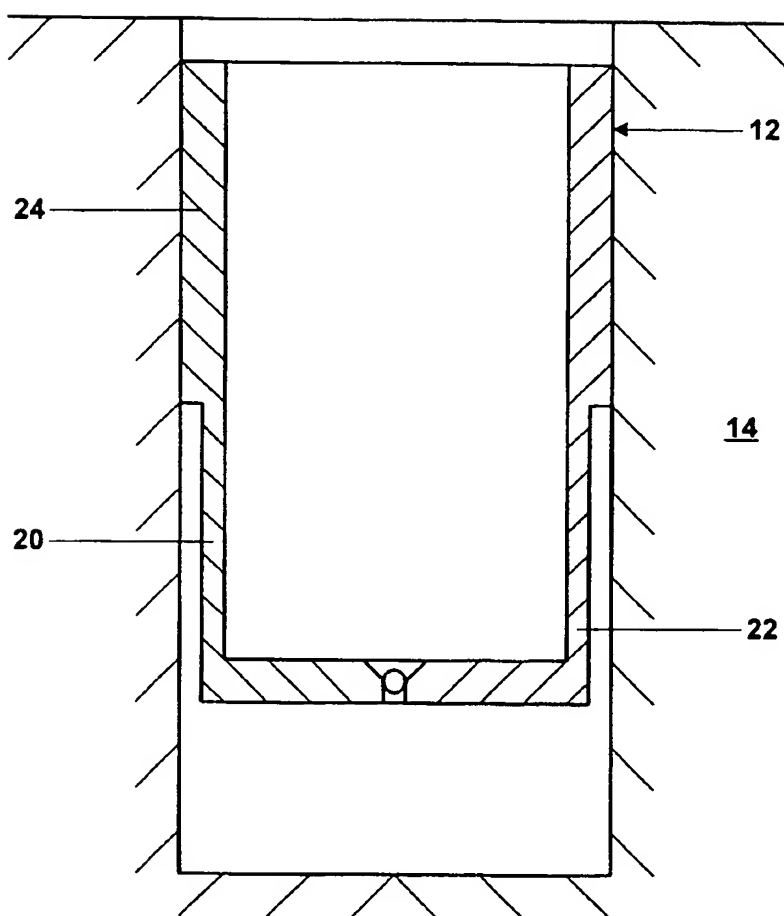


Fig. 4

# INTERNATIONAL SEARCH REPORT

International application No.

PCT/US03/15020

## A. CLASSIFICATION OF SUBJECT MATTER

IPC(7) : E21B 23/04, 23/08

US CL : 166/212, 383, 384

According to International Patent Classification (IPC) or to both national classification and IPC

## B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)  
U.S. : Please See Continuation Sheet

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

## C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 6,085,838 (VERCAEMER et al.) 11 July 2000 (11.07.2000); Abstract; Figures 2 and 5-7; Column 2, lines 40-57; Column 3, lines 41-67; Column 7, lines 26-65	1-30
X	US 2001/0047870 A1 (COOK et al.) 06 December 2001 (06.12.2001); Abstract; Figures 1-4; paragraphs [0044]-[0086]	1-30
X, P	US 6,470,966 B2 (COOK et al.) 29 October 2002 (29.10.2002); Abstract; Figures 1-4; Column 4, lines 59-67; Columns 5-10; Column 11, lines 1-12.	1-30
X, P	US 6,497,289 B1 (COOK et al.) 24 December 2002 (24.12.2002); Abstract; Figures 1-4; Column 4, lines 55-67; Columns 5-10; Column 11, lines 1-7.	1-30
X, E	US 6,575,240 B1 (COOK et al.) 10 June 2003 (10.06.2003); Abstract; Figures 1-5; Column 3, lines 4-30; column 4, lines 39-53; Column 5, lines 15-22 and 51-67; Columns	1-30
A	US 5,348,095 (WORRALL et al.) 20 September 1994 (20.09.1994); entire document.	1-34
A	US 5,667,011 (GILL et al.) 16 September 1997 (16.09.1997); entire document.	1-34
A	US 5,366,012 (LOHBECK) 22 November 1994 (22.11.1994); entire document.	1-34

☐ Further documents are listed in the continuation of Box C.

☐ See patent family annex.

\* Special categories of cited documents:

\*A\* document defining the general state of the art which is not considered to be of particular relevance

\*E\* earlier application or patent published on or after the international filing date

\*L\* document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

\*O\* document referring to an oral disclosure, use, exhibition or other means

\*P\* document published prior to the international filing date but later than the priority date claimed

\*T\*

later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

\*X\*

document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

\*Y\*

document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

\*A\*

document member of the same patent family

Date of the actual completion of the international search

09 July 2003 (09.07.2003)

Date of mailing of the international search report

30 JUL 2003

Name and mailing address of the ISA/US

Mail Stop PCT, Attn: ISA/US  
Commissioner for Patents  
P.O. Box 1450  
Alexandria, Virginia 22313-1450

Facsimile No. (703)305-3230

Authorized officer

David J Bagnell

Telephone No. (703) 308-1020

**INTERNATIONAL SEARCH REPORT**

PCT/US03/15020

Continuation of B. **FIELDS SEARCHED** Item 1:  
166/206, 207, 208

E21B 23/00, 43/10

**This Page is Inserted by IFW Indexing and Scanning  
Operations and is not part of the Official Record**

**BEST AVAILABLE IMAGES**

Defective images within this document are accurate representations of the original documents submitted by the applicant.

Defects in the images include but are not limited to the items checked:

- ☐ BLACK BORDERS
- ☐ IMAGE CUT OFF AT TOP, BOTTOM OR SIDES
- ☐ FADED TEXT OR DRAWING
- ☐ BLURRED OR ILLEGIBLE TEXT OR DRAWING
- ☐ SKEWED/SLANTED IMAGES
- ☒ COLOR OR BLACK AND WHITE PHOTOGRAPHS
- ☐ GRAY SCALE DOCUMENTS
- ☒ LINES OR MARKS ON ORIGINAL DOCUMENT
- ☐ REFERENCE(S) OR EXHIBIT(S) SUBMITTED ARE POOR QUALITY
- ☐ OTHER: \_\_\_\_\_

**IMAGES ARE BEST AVAILABLE COPY.**

**As rescanning these documents will not correct the image problems checked, please do not report these problems to the IFW Image Problem Mailbox.**